Bringing Science to Justices

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California Court of Appeals justice Thomas E. Hollenhorst jokes that he and many other judges chose law as a career to escape science and math. "I think that for the typical judge, there was a Y in the road when they started college about whether they were going to be involved in hard science or soft science," he says. "I think that many of them fled to soft science because they didn't have the wiring to do hard science, and they've continued to just stay away from it."

For science-averse judges everywhere, however, those days are over. Ever since 1993, when the U.S. Supreme Court ruled in *Daubert* v. *Merrell Dow Pharmaceuticals* that federal judges must take greater responsibility in weeding out unreliable "junk science" in courts, the judicial remove from hard science has been shrinking. Even though *Daubert* applied only to federal courts, most states have since adopted similar standards. At the same time, the development of the Human Genome Project and the explosion of legal and ethical questions surrounding genetics are bringing science into the courtroom like never before.

In response to this growing need for greater judicial scientific knowledge, the NIEHS and the U.S. Department of Energy have joined together to provide funding for the Einstein Institute for Science, Health and the Courts (EINSHAC), a nongovernmental organization created in 1993 to educate judges about genetic science. EINSHAC enthusiast James K. Selkirk, who is deputy director of the National Center for Toxicogenomics at the NIEHS, says that NIEHS director Kenneth Olden saw a need for an entity to help jurists deal with their new responsibilities. "Ultimately, part of our goal as an institute is not only to seek scientific truths, but to communicate those truths out to the world," Selkirk says. "EINSHAC is a venue by which judges can be educated in information they're not routinely exposed to in their legal training."

Reaching a Level of Comfort

According to lawyer Franklin Zweig, who has served full-time as president of EINSHAC from its start, the organization has conducted 37 programs to date and built its network of participating judges—who, because of limited resources, must be invited by other EINSHAC judges—to about 3,000. As its numbers have grown, so has the breadth of EINSHAC's interest. In addition to genetics, EINSHAC programs now examine environmental science, molecular biology, biotechnology, and bioterrorism.

"Our mission," Zweig says, "is to make the science understandable, to extract the mystique, and render it in 'plain vanilla' so that judges, who tend to be phobic about science, have a better chance of accessing it and turning its implications into procedural benefits for case management."

EINSHAC events, which are run primarily by judges and a few scientists, range from half-day seminars to larger conferences of several days. Typically, each event features one topic that gets broken down into subtopics addressed by keynote speakers and discussion panels. In "adjudication clinics," small groups of about a dozen judges break out to discuss hypothetical cases with a scientific advisor. "We don't prescribe outcomes," Zweig says. "[The judges are] the decision makers; they must determine the outcomes."

Although EINSHAC strives to provide judges with comprehensive scientific information, its objective in doing so is much narrower. "We seek to increase judges' comfort and confidence that they can control the expert testimony in a proceeding," Zweig says. "We find that that's the most valuable objective for judges, whose main gatekeeping role is to determine what

evidence should be brought in and what should be excluded."

In the case of bioterrorism education, however, the goal is broader. Rufus G. King III, chief judge of the Superior Court for the District of Columbia, has been an EINSHAC bioterrorism panel member several times, and he says it's helped him and others come to grips with a variety of administrative questions related to bioterrorism. For instance, King says, "What if a lawyer comes up and says, 'My client has told me that he [possesses the smallpox virus] and that he's doing everything he can to see that everyone in the building dies'? What do you do? You're responsible; this is your courtroom. Do you close the court? Do you excuse people? Do you get that person into the cell block?"

Taking It to the Courtroom

One judge, who requested anonymity, listed several ways in which her EINSHAC experience helped her in determining real-life outcomes. In one, a medical negligence case, the lawyers and their scientific experts were vigorously arguing whether the matter would ever get to a jury. The judge's EINSHAC training helped her recognize the scientific problems the case would face if it went to trial at that point. "Because of my EINSHAC experience, I was able to suggest that they go on their own to a neutral scientist for evaluation [of the evidence]," she says. "I actually suggested a doctor who's never in the court system; he doesn't participate in the adversary process and has a very good reputation. They went to him, and the case disappeared."

She credits her EINSHAC education for providing a "certain comfort level with science" that has convinced her twice to disqualify scientific experts during trial because they lacked the competence necessary for the case—not something a judge does lightly. In one of the situations, the case disappeared because the parties couldn't come up with the qualified expert required by the judge. In the second, the dismissal was upheld on appeal.

In addition, says this same judge, her experience with EINSHAC gave her the idea of providing case-specific scientific glossaries for jurors, which she has used several times at trial. "Every juror in the box has a long glossary of terms so that when these terms are used by the experts, they can look at them and understand what's being said," she says. "I require the lawyers to agree on the glossary; they have to write it up."

The primary EINSHAC goal of helping judges better identify the scientific evidence to be allowed at trial doesn't apply to appellate judges, who can't bring new evidence into their review of lower courts' findings. But Hollenhorst said that his EINSHAC education has still been helpful. "At the appellate level, it gives us a much better encyclopedia to deal with terminology and the correctness of assertions that have been made in the trial court," he says. "It's caused me to look at the scientific issues with a more discerning eye about how they were handled."

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–Franklin Zweig
EINSHAC

King says that his own education from EINSHAC greatly increased his comfort with DNA evidence in criminal trials involving serious felonies such as murder and rape. It also gave him an idea: why not develop some basic scientific materials to guide jurors when they hear complex scientific cases? The result, in 2001, was a 25-minute video that explains basic DNA science. "Now, instead of a juror's first experience with any DNA science being from an expert who has a motive, their first exposure is from somebody trying to give them sort of a high-school-level background on it," he says. "Then, when they start to listen to the experts, who are perhaps trying to exert a particular spin, there's a little greater level of sophistication." King has used the video in court and made copies available at EINSHAC programs, where, he says, they are very popular.

Widening Perspectives

One EINSHAC program, the Genetics Adjudication Resource Project, or GARP, is designed to assist judges by predicting new kinds of cases that may arise from the Human Genome Project's mapping of all human genes. Judge Pauline Newman of the U.S. Court of Appeals for the Federal Circuit, who chairs the GARP Advisory and Review Committee, says, "The committee's job is to keep track of everything that's being done and is proposed to be done, and to provide advice, suggestions, and critical commentary on it." (Newman has a Ph.D. in chemistry and worked as a chemist before switching to law.)

In following the science, EINSHAC is taking on a more global perspective, according to Zweig. "When we started, we focused on federal and state courts exclusively, but as the science clearly [spread] across the globe and the disputes inspired by science and technology became more and more international, we started and enhanced an international focus."

To that end, EINSHAC judges have traveled to other countries to discuss what they've learned about scientific advances in the United States. Those trips are part of an EINSHAC project called International Working Conversations, which will conclude in mid-2004 with the Third Courts International Working Conversation on Enviro-Genetics Disputes and Issues in Australia, and the subsequent publication of an international guidebook on court management of life science technology disputes and evidence.

Where science deals in broad data about probabilities, courts operate on a case-by-case basis. This creates an inherent uneasiness between the two, and one of EINSHAC's goals is to reduce that uneasiness. Sheila Newton, director of the NIEHS Office of Policy, Planning, and Evaluation, uses the analogy of a chemical exposure level to demonstrate the difference between the two realms: Where a scientific study may be able to identify what percentage of a group of people will be affected by a specific exposure level, courts are interested in determining whether an individual is likely to have sustained an injury due to an exposure, she says. The process for determining justice based on scientific probabilities is difficult, but judges are the ones who have to make it work, Newton says. "That's why we think that the work that EINSHAC is doing is so critical." **–Richard Dahl**

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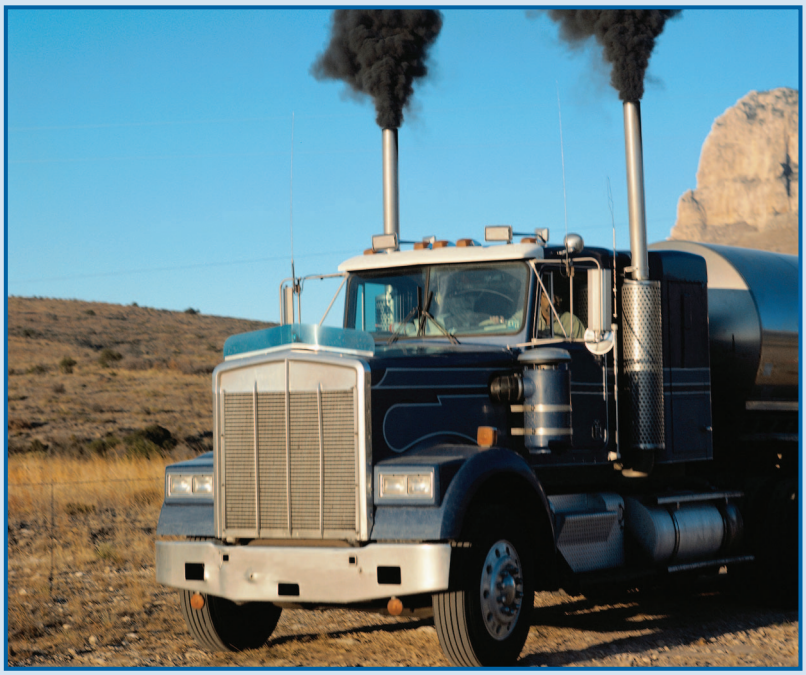

Understanding Effects of Organic Diesel Exhaust Particles

Li N, Wang M, Oberley TD, Sempf JM, Nel AE. 2002. Comparison of the pro-oxidative and proinflammatory effects of organic diesel exhaust particle chemicals in bronchial epithelial cells and macrophages. J Immunol 169:4531–4541.

Numerous epidemiologic studies have shown that exposure to ambient particulate matter (PM) can exacerbate asthma and cause allergic inflammation. Diesel exhaust particles (DEPs)—an easily respirable component of PM—are known to cause proinflammatory effects in the respiratory tract. Although much is known about how DEPs affect macrophages, it is not known how the oxidative stress response differs between macrophages and epithelial cells, two primary cell targets of PM. New research by NIEHS grantee Andreas Nel and colleagues at the University of California at Los Angeles sheds light on these differences, as well as on mechanisms by which exposure to DEPs may adversely affect the respiratory system by inducing oxidative stress in bronchial epithelial cells.

DEPs consist of a carbonaceous core with a large surface area to which chemicals—including organic chemicals such as polycyclic aromatic hydrocarbons and their oxygenated derivatives—are absorbed. The researchers extracted organic chemicals from DEPs and applied them in culture to macrophages and bronchial epithelial cells. Then they compared the responses.

The researchers demonstrated that oxidative stress in epithelial cells caused the formation of heme oxygenase 1 and other markers. Although macrophages responded in a similar manner, epithelial cells produced more superoxide radicals and were more sensitive to cytotoxic effects resulting from mitochondrial damage, superoxide production, and energy depletion. In addition, the thiol antioxidant *N*-acetylcysteine protected macrophages against cytotoxic DEP chemicals but did not protect epithelial cells.

According to the researchers, these findings show that organic DEP chemicals induce a range of oxidative stress–related biological responses in epithelial cells and macrophages. They propose that this constitutes a stratified cellular response to oxidative stress, with the activation threshold for cellular injury requiring higher oxidative stress levels than those for cytoprotective responses. A stratified oxidative stress model in which biological end points are selected relevant to the level of oxidative stress and PM exposure may therefore prove useful in study of the adverse health effects of PM, they say. **–Jerry Phelps**

Coming Together for Children

When it comes to environmental exposures and health, children are not just small adults. They also aren't "big rats," quipped Daniel Swartz, executive director of the Children's Environmental Health Network, a national organization devoted to protecting the fetus and child from environmental health hazards and promoting healthy surroundings. His remark drew a round of laughs, yet resounded with participants at a recent symposium titled "Children's Environmental Health: Identifying and Preventing Environmental Threats to Children." The attendees knew all too well that rodent studies are particularly difficult—even impossible—to accurately extrapolate to children.

Fortunately, the field of children's environmental health has moved beyond merely recognizing the unique vulnerability of children—it has advanced to understanding why and how they are more vulnerable than adults and toward developing and implementing ways to protect children, said Elaine Faustman, director of the Institute for Risk Analysis and Risk Communication at the University of Washington School of Public Health and Community Medicine in Seattle. Faustman helped plan the 24–26 February 2003 conference.

"We're in the midst right now of a scientific revolution about the links between environment and health that will provide tremendous opportunities to protect health," said John Peterson Myers, a senior research associate with Commonweal, an environmental research institute in Bolinas, California, and coauthor of the 1996 book *Our Stolen Future*. "The revolution, as it unfolds, will require a complete overhaul not only of specific regulatory standards, but of the entire approach that has been used to protect public health from environmental exposure."

Much work remains not only to fill existing research gaps but to successfully put policy and prevention efforts in place. "It's simply not enough to do a good basic science study, publish in the very best journals, and there it sits," asserted NIEHS director Kenneth Olden. "We want that information translated into public health policy and the practice of medicine. In order to do that, you need people, you need communities, you need stakeholders, you need

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journalists, you need everybody. So that's what this conference did—it brought everybody together."

Profiling Threats to Children

Besides assembling leaders in environmental health research, policy, community outreach, and communications, the conference succeeded in achieving its core goals, according to symposium planning committee members, who included NIEHS staff David Brown, Gwen Collman, and Kevin Wheeler. The main objectives included profiling environmental threats to children, addressing ways to translate science into action to protect children, identifying research gaps and initiating plans to fill them, and discussing ways to better communicate risk through strengthened media relations.

The symposium was divided into five key areas: respiratory disease and air quality, neurological impairments, childhood cancer, birth defects, and endocrine disruption. For each issue area, presenters and panelists discussed the current state of the knowledge, its application, research gaps, how research findings are being implemented in children's health care, implications for outreach policy, and communications and media relations by researchers and policy makers. Olden noted that other research areas such as violence and accidents are also important to children's environmental health, although they were not emphasized in the program agenda.

A general consensus was expressed across many broad themes at the conference. "Prevention of exposure is the single most effective means of protection against environmental threats," said Terri Damstra, a scientist in the International Programme on Chemical Safety Interregional Research Unit of the World Health Organization.

Moreover, in human health the timing of exposure remains the most critical factor in disease outcomes. In particular, a growing number of experts believe that fetal programming—critical exposures in the womb that can impact a child's development and health for life—will turn out to be a vital part of the story. "We will leave children behind [in terms of education and health] if we don't get a handle on exposure in the womb and early development," said Rich Liroff, policy director of the World Wildlife Fund's Wildlife and Contaminants Program.

Progress has been made on many fronts, especially research. "The universe of folks engaged in this research is expanding as rapidly as the pace of the science," Myers explained. "New papers are coming out every week, if not every day. Researchers are tackling old problems in new ways and extending the tools to address them." For instance, the growing use and development of increasingly sophisticated geographic information systems is helping researchers get a clearer picture of at-risk populations, reported Marie Lynn Miranda, who directs the Children's Environmental Health Initiative at Duke University.

From Consensus to Direction

Yet, more new approaches and paradigms for thinking about the problems are needed. For a start, "we must develop a more complex model of human diseases," Olden said, one that involves interaction between genetics and environment as a function of age, stage of development, and behavior.

Despite the expanding knowledge base on potentially toxic exposures and the known neurotoxic effects of many compounds, such as those containing mercury and manganese, there has been a lack of research into the effects of children's exposure to such compounds, said Philip Lee, a senior scholar at the Institute for Health Policy Studies at the University of California, San Francisco, School of Medicine. For example, researchers know that manganese is a neurotoxicant that contributes to inattention, impulsivity, and hyperaggression. They also know that infants have virtually no ability to excrete excess manganese. Yet, infants are commonly exposed to manganese at fairly high concentrations in cow's milk and soy formula.

Prevention policies and strategies also need improvement. Lead has been removed from gasoline, plumbing pipes, new paint, and other sources, dramatically reducing childhood blood lead levels nationally. But lead exposure remains a major problem, according to recent papers on the subject. Too many children are still being exposed through sources in old housing, such as old paint, Lee said. Physicians are treating these children after the fact, which is too late, as studies reveal irreversible damage is done even when lead is removed from the blood through chelation therapy.

Olden advocated a three-pronged approach to children's environmental health. First, identify risk factors, be they genetic or environmental, from basic fundamental clinical, community, and population-based studies. Second, develop ways to reduce exposure to those risk factors to prevent their expression. And finally, translate knowledge and scientific information into public health policy and medical practice. "I encourage [NIEHS-funded] scientists to do all three," Olden said. "Without that, we are not doing our job."

"If there's one area where we need improvement in public health and also in science in general, it is risk communication to the public through the media," Lee added. Science and environmental journalists at the symposium encouraged researchers and policy advocates to help the media do its job. They explained the tight time and space constraints, the need

to simplify ideas for a lay audience, and other pressures that journalists face in trying to get stories out, factors that often frustrate scientists. On the other hand, journalists will happily "take spoon-feeding" to ensure they are understanding scientists' stories correctly, said Reuters health and science correspondent Maggie Fox. "Sometimes we can help extend the limits of what can be said on a subject," added Francesca Lyman, a veteran environmental columnist and author.

Moving Forward

Part of the challenge facing researchers is managing the uncertainty entailed in the scientific process. Although work remains to fill the research gaps across the five key areas of children's health covered at the symposium, there will always be uncertainty. It's inherent in the scientific process. For example, the role the environment plays in birth defects is still largely unknown. A recent report estimated the number of birth defects that are environmentally related to be 3–25%. Such a range of uncertainty makes informing the public difficult.

Moreover, calls for more research often end up frustrating the advocacy community. While more research is generally considered a good thing, a call for more research may be a ploy to stall a sound new policy from being implemented. Panelists emphasized the need to implement prevention strategies and take action in the face of uncertainty because that's what the world of research is all about. In many cases, enough data have been collected to implement safer and better practices. It's more a matter of challenging existing perceptions about what is dangerous and improving communication with communities. Policies have not always progressed with the science, but have been mired in a metaphorical Jurassic period, Myers asserted.

Many panelists also encouraged participants to expand the push to improve children's environmental health internationally. Developing countries, in particular, face more daunting threats, especially when compounds outlawed in the United States are still in widespread use there, and prevention, outreach, and policy lag further behind that in this country.

Olden plans to continue working to sustain the momentum that the NIEHS and others have generated in recent years on the children's environmental health front. Together, the NIEHS and the U.S. Environmental Protection Agency have funded 12 children's environmental health research centers, with the first 8 centers opening in 1998. A request for applications for funding of up to 6 new centers was discussed at the meeting. Funding for 8 of the existing 12 centers will run out this fiscal year, but existing centers may reapply under the new request for applications.

For more than 30 years the NIEHS has sponsored research on a host of threats to child health including asthma, birth defects, learning and behavioral disorders, developmental disorders, cancer, and low birth weight. Bringing stakeholders together is one way to further build momentum in this field. "We don't want to lose the enthusiasm generated by this symposium," Olden said. Above all, he said, "I don't want us to forget what we're really talking about are children. These are not bland statistics, but real people."

–Julie Wakefield